TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 770

HYDRODYNAMIC TESTS OF MODELS OF SEAPLANE FLOATS

By Antonio Eula

L'Aerotecnica, Vol. XIV, Nos. 8-9
August-September 1934

Washington
May 1935

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SUMMARY

This report contains the results of tank tests carried out at free trim on seventeen hulls and floats of various types. The data as to the weight on water, trim, and relative resistance for each model are plotted nondimensionally and are referred both to the total weight and to the weight on water. Despite the fact that the experiments were not made systematically, a study of the models and of the test data permits nevertheless some general deductions regarding the forms of floats and their resistance. One specific conclusion is that the best models have a maximum relative resistance not exceeding 20 percent of the total weight.

INTRODUCTION

The present report contains the results of tank tests made on models of seaplane floats. These tests rather than being systematic refer to models of different types selected from a great number of those tested in the laboratory during the last few years. In spite of this and of the smallness of the models, the results are nevertheless of sufficient interest to warrant publication; first, because experimental data are not very abundant, and second, because in addition to the examination of particular cases, it affords an opportunity to draw some general conclusions regarding seaplane floats of given weight, given wing structure, and given position of the center of gravity.

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*"Esperienze idrodinamiche di modelli di galleggianti d'idrovolante (1^a serie)." L'Aerotecnica, August-September 1934, pp. 947-990.

Test Procedure and Results

The tests were all made free to trim using the parallelogram balances with wooden frame, according to the method described in a previous report.* The aerodynamic lift was deduced from the results of aerodynamic tests with the complete seaplane models. The measurements were made by Carlo Bettaccini, chief engineer of the towing tank.

The models were divided into four classes: A) single hulls, B) twin floats, C) single floats, and D) twin hulls. Each model is represented in both profile and plan views with the sections shown at double scale for greater clearness. The dimensions shown on the plans correspond to those of the models. The principal geometric characteristics of the models are given in the table, both in absolute values and in the form of ratios; in particular, the position of the c.g. and of the thrust line are given. The table also shows the weight, model scale, and for the floats, the reserve buoyancy. These data were not calculated for the hulls because the volume of the hulls is determined from other factors than the buoyancy, and the excess buoyancy is always quite plentiful. In a final table the principal geometric and hydrodynamic data of the models are tabulated and compared.

The hydrodynamic characteristics of the floats are shown in a diagram having four curves whose abscissas and ordinates are all nondimensional. One gives the values of the angle of trim θ with respect to the load water line; this latter is drawn on the longitudinal section of the float and on it is also shown the angle of wing setting (i^o). The other curves are, respectively: ratio (ξ) of weight on water (total weight less aerodynamic lift) to total weight; ratio (ϵ) of resistance to total weight; and ratio (ϵ_r) of resistance to weight on water. The maximum values of ϵ and ϵ_r are included in the summarizing table along with the geometric characteristics.

The relative resistance indicates the hydrodynamic quality of the float, which evidently is better as the values of ϵ are lower. These ratios, and particularly that of the resistance to weight on water, correspond to the drag/lift ratio of wings (the so-called "fineness

*The Hydrodynamic Laboratory of the Air Ministry for Advanced Research and Testing. L'Aerotecnica, April 1932.

ratio"). It was decided to show the relative resistances instead of the inverse ratios, as the latter become infinite at zero velocity and thus preclude the reading of the curves at the lowest velocities. The ϵ curve would have a zero ordinate at get-away speeds, which is usually not the case in tests, were it not that the aerodynamic resistance of the model is included in the measured resistance; the ϵ_r curve would tend to become indeterminate at such speeds because $\epsilon_r = 0/0$, so that at high speeds the ϵ_r curves may even be rising.

In order to make the abscissas nondimensional it was obviously necessary to represent on the corresponding axis the ratio of two speeds. This ratio was defined in the most convenient way. The most common method is that of referring to the ratio of test speed to take-off speed of the model; but since the tests were made free to trim, the latter speed is not exactly defined because it is tied up with the changes in trim which in turn depend on the pilot's maneuvers.

The simpler, even though not the most probable assumption, is that of supposing the take-off to occur at the trim, corresponding to the angle of attack of the wing giving maximum lift.

However, whether with these assumptions or with others which might be made, the values of the abscissas would remain linked closely to the aerodynamic characteristics of the wing system, what is desired is to make the results as general as possible from the hydrodynamic point of view.

Accordingly, it is believed convenient to define the abscissas as the ratio of the test speed to that of maximum resistance, which is shown on the table with the other fundamental data. In this manner the maximum of the curve of relative resistance with respect to the total weight always corresponds to abscissa 1. In order to recognize in experimental cases the ratio of take-off speed, corresponding to maximum wing lift, and maximum resistance, the values of this ratio are marked with a cross on the scale of the abscissas.

Utilization of the Results

The results of the hydrodynamic tests on floats are less amenable to generalization than those of aerodynamic tests. Take the case of a wing, for example. If the scale effect is disregarded, which with appropriate test methods already introduced in modern science can even be eliminated altogether, the nondimensional coefficients taken from the model may be applied to any similar wing under identical conditions. On the other hand, in the case of floats - in addition to the scale effect which is high for small models - there is, further, the ratio of weight to volume, which determines the draft of the floats, the formation of waves, etc.

For this reason the values of the resistance-weight ratio taken from model tests are applicable to the case of full-size floats only within certain limits; that is, only on the basis of a restrictive assumption regarding the changes of weight with the dimensions. This obviously limits the scope of the results from a practical point of view.

7 In order to apply the test results made on the basis of Froude's law of similitude (which is the one adopted in nearly all test tanks despite the fact that it makes no allowance for the viscosity effect) to the case of a full-size float of different dimensions from those corresponding to the scale of the model, it is obviously necessary to proceed on the assumption that the total weight of the seaplane varies as the third power of the ratio of linear dimensions. Then the corresponding speeds vary as $\sqrt{\lambda}$, and the actual hydrodynamic resistance of a seaplane of given dimensions at any speed is obtained from the diagrams defining the ratio of this speed to that of the maximum resistance (equal to the critical speed of the model multiplied by $\sqrt{\lambda}$) and reading in accordance with this the value of the relative resistance from the ϵ curve which, with weight noted, gives the hydrodynamic resistance of the seaplane in absolute values.

Naturally it must be assumed that the relative position of the center of gravity remains unchanged with dimensional changes.

To admit the foregoing assumptions means to maintain unchanged, with changed dimensions, the reserve buoyancy, which might be logical on the whole although for the inhabited hulls this reserve does not result in stability from considerations of safety, but is contingent upon practical reasons. When increasing the size of the seaplane, we must not only consider the floats; the wing system must also be taken into account.

Since the ratio ξ of weight on water to total weight is unchanged even when the dimensions are changed, it is necessary that the wing lift also change with λ^3. It is necessary, in other words, as will be shown directly, that the dimensions of the wings likewise increase in the same ratio as the hull, so that the wing loading may increase in ratio λ.

Now, the few examples of seaplanes enlarged in size in quasi similitude show effectively that the wing loading increases with the dimensions. This is the case with the "Dornier Wal", "Superwal" and the "Do-X". But the hulls of these three are unlike and consequently we lack a basis for comparison. This is logical since with higher wing loading the strength requirements of the floats are changed and hence the form must change also.

In conclusion, even when disregarding the position of the center of gravity, the extrapolation of the data obtained in the towing tank on floats of dimensions and weights other than those fixed by the model scale is subject to restrictive assumptions and consequently, must be analyzed for each particular case; that is, at least when the tests are made with one initial weight figure.

Deductions of Geometric Characteristics

An examination of the dimensions and shapes of experimental models, even aside from those discussed here, makes it possible to determine mean values for certain ratios of form and certain angles used in construction which may be very useful to the designer. Admittedly, these values do not refer in their totality to floats of unorthodox design as, for instance, the C-2, fitted with longitudinal steps, designed to assure transverse stability; or the hull of the A-5, although it is stable of itself and is for that reason exceptionally broad-beamed.

The ratio L/l varies from 7 to 8 for hulls; from 5.5 to 8 for twin floats.

The mean value of ratio $H/L = 0.11$.

Ratio M/L varies from 0.4 to 0.5.

The ratio $M-X/M$ is always positive (the center of gravity is forward of the step) but is subject to considerable variations; it amounts, at maximum in the models tested, to 6.5 percent. (For explanation of the symbols, see figs. 5 to 38.) Mr. Bettaccini was, however, able to establish a relationship between length, beam, and total weight, as shown in figures 1 and 2 for the hulls, and the twin floats, respectively. According to the curves the differences are very minute. However, with reference to figures 3 and 4, we immediately find:

$$\alpha=30^\circ-35^\circ;\quad \beta_1=7^\circ-10^\circ;\quad \beta_2=10^\circ-14^\circ;\quad \frac{d}{l}=3.6-5$$

Hydrodynamic Results

From a study of the curves and the table summarizing the principal results, we deduce that the value of ϵ_{max} ranges, for normal floats, between 0.20 and 0.30. The lower values are shown for some hulls, while for floats they generally do not drop below 0.25.

The float bottoms giving rise to lower resistance are those of slight V bottom and with triply divided bottoms. The A-5 model with triply divided bottom and with a skeg between the two steps shows the high value of 0.26, evidently because of the relatively broad beam.

The maximum resistance corresponds generally to a load on the water varying between 80 and 90 percent of the whole; the percentage is higher for twin floats than for hulls.

The relative resistance with respect to the weight on water varies from 0.25 to 0.35, but sometimes their maximum is not definable. Floats considered as wings have then a maximum hydrodynamic efficiency which at best amounts to 4.

The ratio of take-off speed calculated on the basis of maximum wing lift to that of the maximum resistance depends on the wing loading and varies between 2 and 3.5.

The models showing greater angles of trim are usually those having a higher resistance.

CONCLUSIONS

In conclusion it may be stated that, allowing for the scale effect, estimable at around 15 percent, the better hulls under normal conditions of loading have a maximum hydrodynamic resistance which may even go below 20 percent of the weight, while the percentage for twin floats is slightly higher.

The figures and diagrams refer to the different models.

Translation by J. Vanier,
National Advisory Committee
for Aeronautics.

Table of Principal Geometric and Hydrodynamic Data of the Models

Figure No.	Type	$\frac{L}{l}$	$\frac{H}{L}$	$\frac{M}{L}$	$\frac{M-X}{M}$	$\frac{Y}{H}$	Scale of model λ	Weight of model P = kg	Velocity of maximum resistance $V_{r_{max}}$ = m/s	Maximum angle of trim ϑ^{o}_{max}	ϵ_{max}	$\epsilon_{r_{max}}$
5- 6	A_1	7.18	0.125	0.408	0.0385	1.410	1:10	1.890	3.10	7^{o}	0.200	0.24
7- 8	A_2	6.88	.134	.376	.0296	1.510	1:9	2.100	3.08	$11^{o}10'$	.275	increasing
9-10	A_3	5.08	.127	.384	.0087	1.135	1:12.65	2 -	3.35	8^{o}	.250	"
11-12	A_4	5.65	.119	L_1 = .380 L_2 = .620	.0454	1.410	1:14.5	1.305	3.05	7^{o}	.220	0.280
13-14	A_5	4.70	.113	L_1 = .434 L_2 = .642	.0373	1.240	1:25	2.241	3 -	$8^{o}10'$	.260	.320
15-16	A_6	7.06	.133	.403	.0375	.985	1:20	1.750	3.02	5^{o}	.210	.250
17-18	A_7	7.85	.098	.415	.0364	1.680	1:15	1.778	1.90	8^{o}	.255	.275
19-20	A_8	7.75	.095	.433	.0130	1.700	1:15	1.778	3.10	8^{o}	.250	.320
21-22	B_1	8.45	.104	.535	.0445	2.920	1:10	.350	2.50	7^{o}	.230	.275
23-24	B_2	6.18	.119	.475	.0193	2.280	1:15	.740	3.18	11^{o}	.250	.310
25-26	B_3	7.80	.114	.518	.0084	2.650	1:15	.742	2.60	11^{o}	.325	.425
27-28	B_4	7.91	.111	.523	.0534	1.645	1:10	.803	2.38	7^{o}	.300	increasing
29-30	B_5	7.93	.111	.520	.0628	1.640	1:10	.803	2.42	$7^{o}10'$	.290	0.350
31-32	B_6	7.98	.125	.523	.0650	2.420	1:15	1.333	2.92	$8^{o}20'$	.250	.295
33-34	C_1	6.05	.095	.511	.0390	2.88	1:16	.462	2.42	$9^{o}40'$	.240	.290
35-36	C_2	2.07	.084	.578	.0110	3.42	1:10	1.720	2.50	$13^{o}30'$	.325	.350
37-39	D_1	5.35	.137	.497	.0198	1.53	1:20	.812	2.76	$5^{o}40'$	.240	increasing

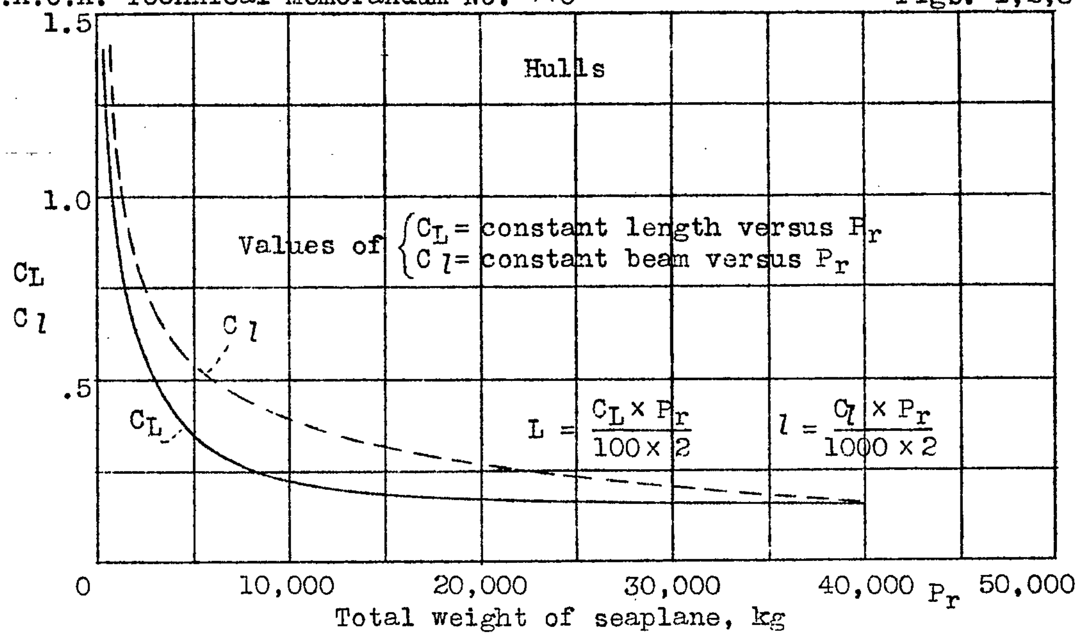


Figure 1.

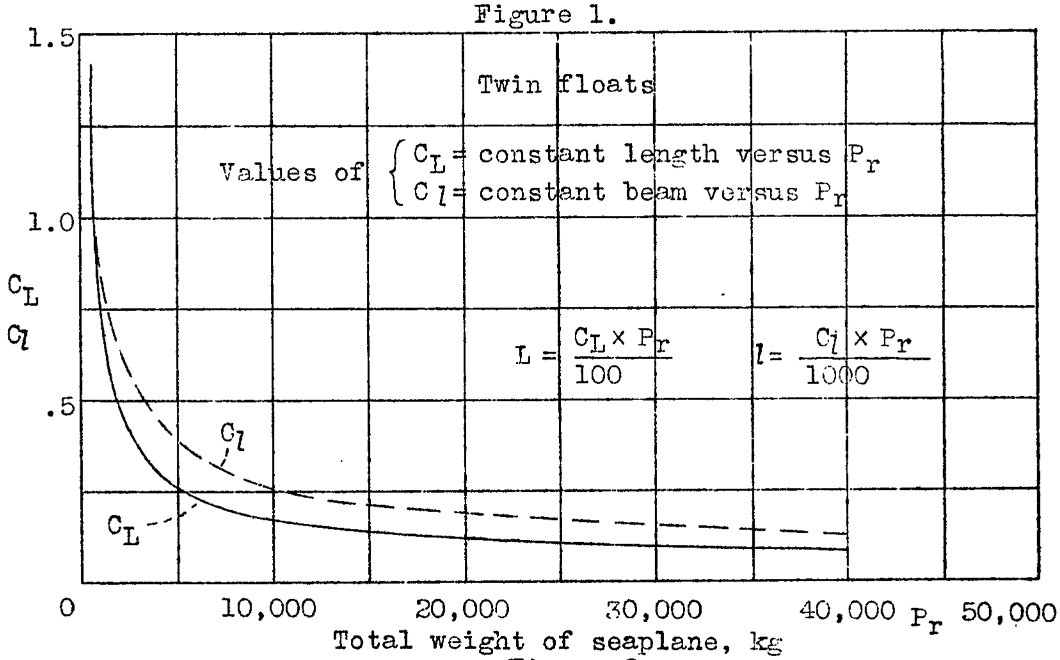


Figure 2.

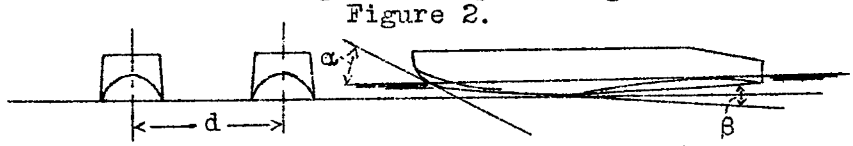
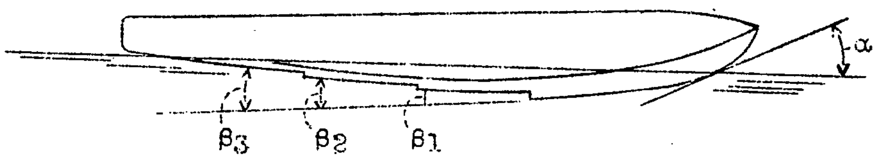


Figure 3.



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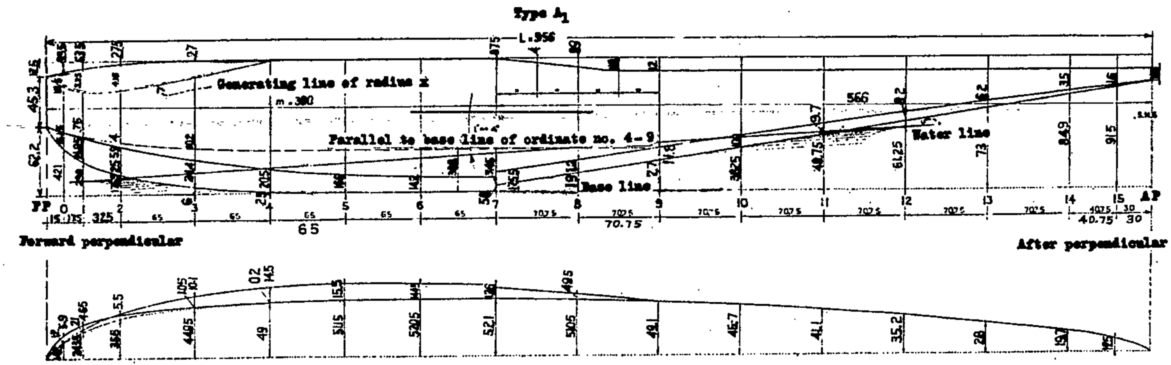
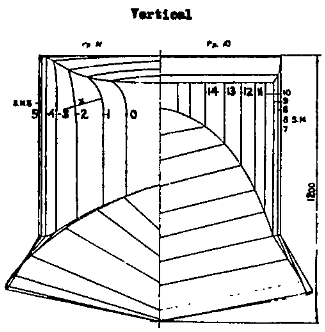




Length between perpendiculars	L = 956 mm
Beam, maximum	l = 133 mm
Depth	H = 120 mm
Distance of step aft of forward perpendicular (FP)	M = 390 mm
Beam at step	b = 129.4 mm
L/l = 7.18 H/L = 0.125 M/L = 0.408	
Distance of c.g. aft of F.P.	X = 375 mm
Distance of c.g. above base line	Y = 169.5 mm
Weight of model (to scale)	P = 1.890 kg
Height of thrust line above base line	Y_T = 248.5 mm
$M-X/M$ = 0.0385 Y/H = 1.410	

P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i_0 = angle of wing setting relative to water line = 4°
d = track of twin floats Δ = weight on water
Scale of model 1 : 10

Figure 5.

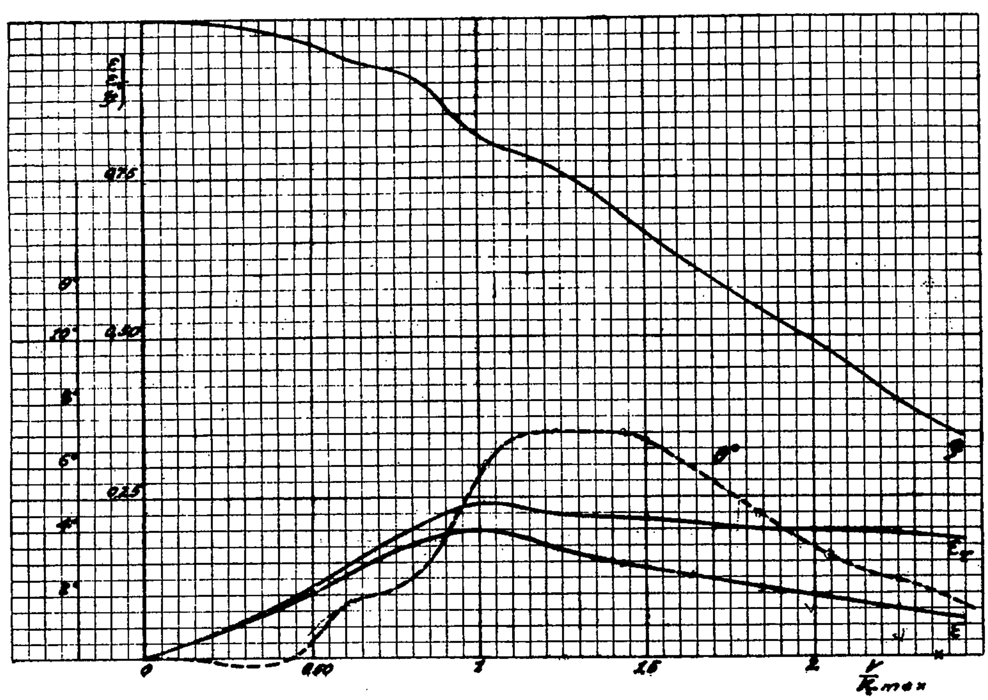
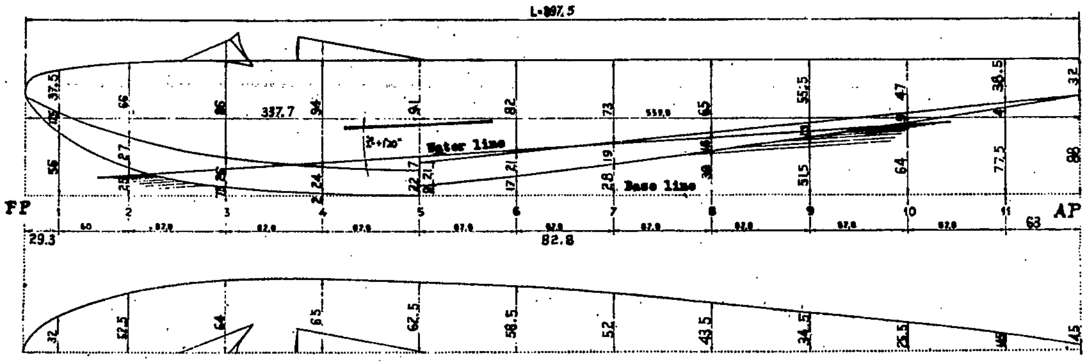
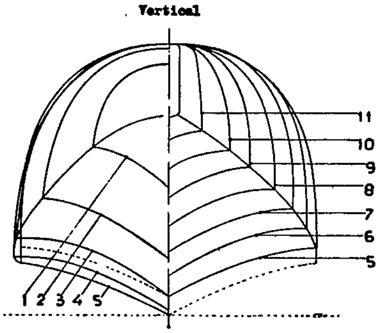


Figure 6.





Length between perpendiculars	L = 897.5 mm
Beam, maximum	l = 130 mm
Depth	H = 120 mm
Distance of step aft of forward perpendicular (FP)	M = 337.7 mm
Beam at step	b = 125 mm
L/l = 6.88 H/L = 0.134 M/L = 0.376	
Distance of c.g. aft of F.P.	X = 327.8 mm
Distance of c.g. above base line	Y = 181.9 mm
Weight of model (to scale)	P = 2,100 kg
Height of thrust line above base line	Y_T = 246.8 mm
M-X/M = 0.0296 Y/X = 1.510	

P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^0 = angle of wing setting relative to water line = 1° 20'
d = track of twin floats Δ = weight on water
Scale of model 1 : 9

Figure 7.

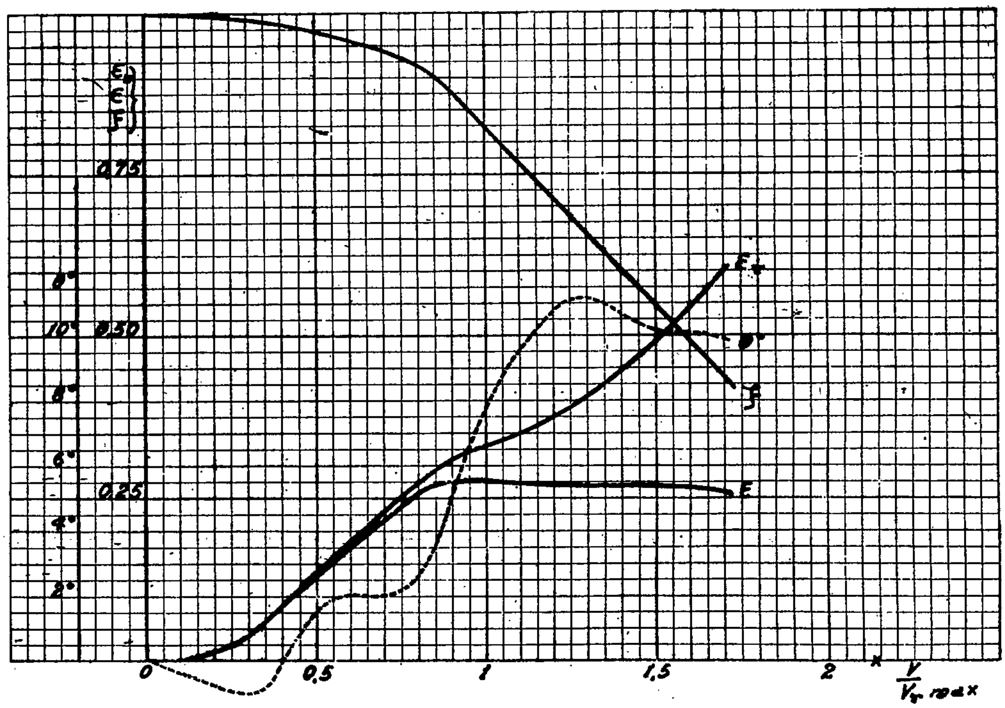
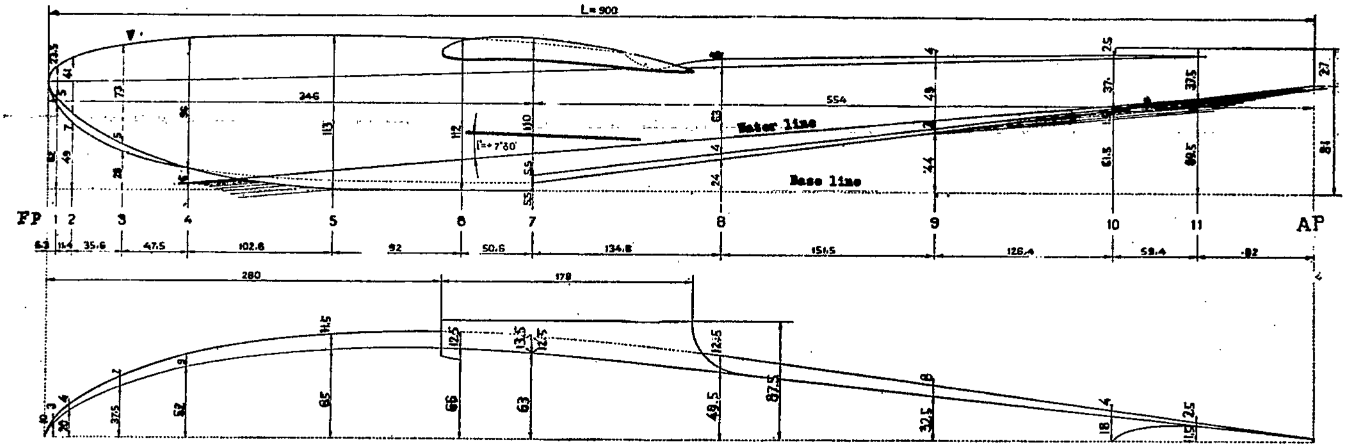
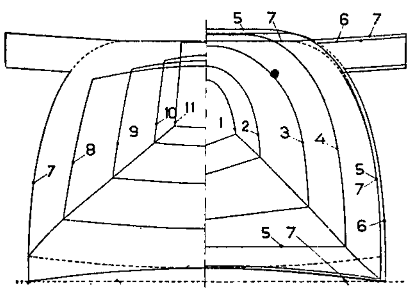


Figure 8.





Length between perpendiculars L = 900 mm
Beam, maximum l = 177 mm
Depth H = 114 mm
Distance of step aft of forward perpendicular (FP) M = 346 mm
Beam at step b = 156 mm
L/l = 5.08 H/L = 0.127 M/L = 0.348
Distance of c.g. aft of F.P. X = 343 mm
Distance of c.g. above base line Y = 120.5 mm
Weight of model (to scale) P = 2.00 kg
Height of thrust line above base line Y_T = 217 mm
M-X/M = 0.0087 Y/H = 1.135
P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
d = track of twin floats Δ = weight on water
i° = angle of wing setting relative to water line = 7° 30'
Scale of model 1 : 12.65

Figure 9.

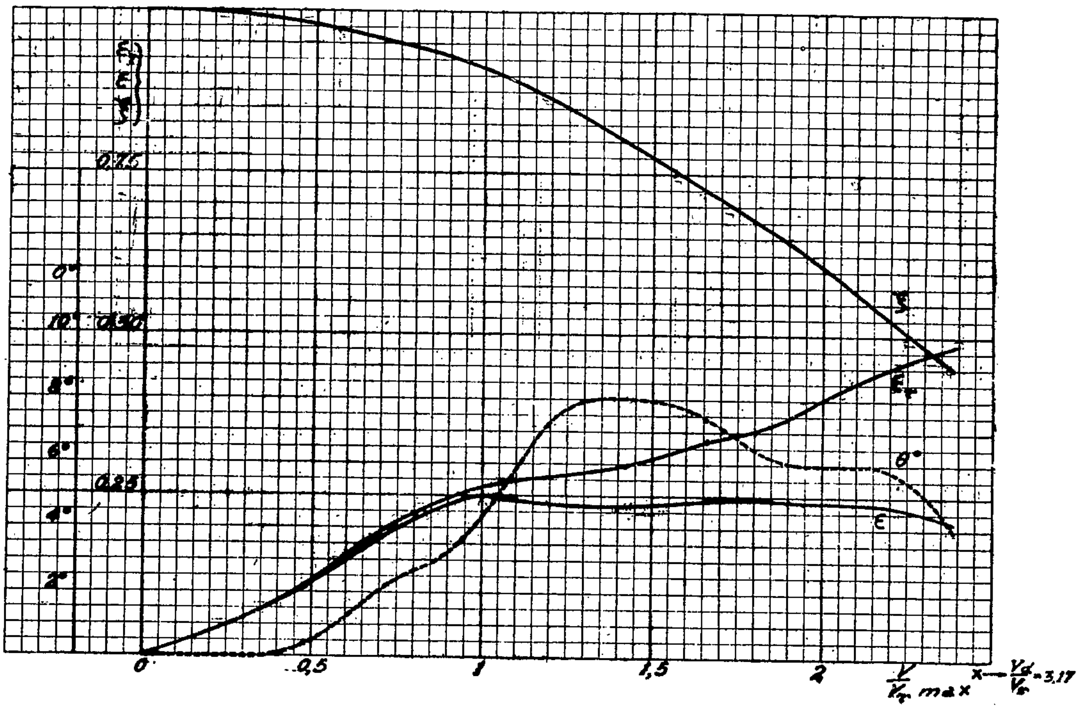
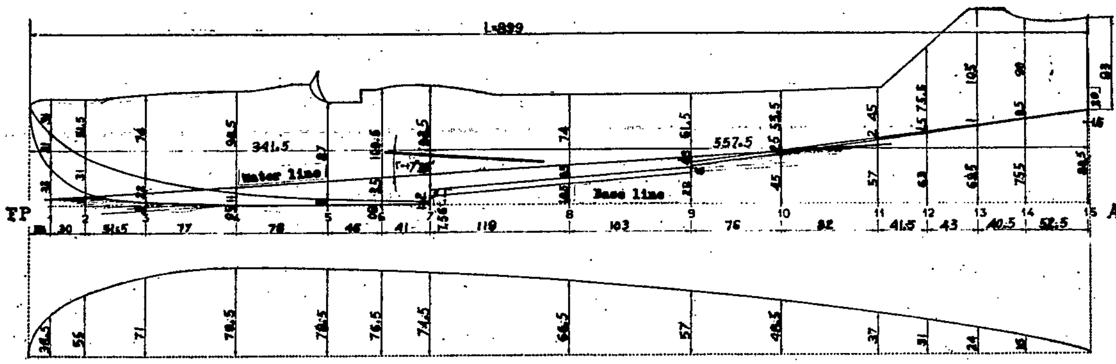
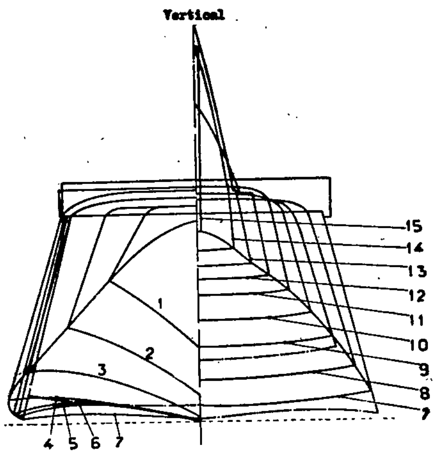


Figure 10.





Length between perpendiculars		$L = 899$ mm
Beam, maximum		$l = 159$ mm
Depth		$P = 107$ mm
Distance of step aft of forward perpendicular (FP)	$M =$	$L_1 = 341$ mm $L_2 = 563.5$ mm
Beam at step	$b =$	$b_1 = 190$ mm $b_2 = 114$ mm

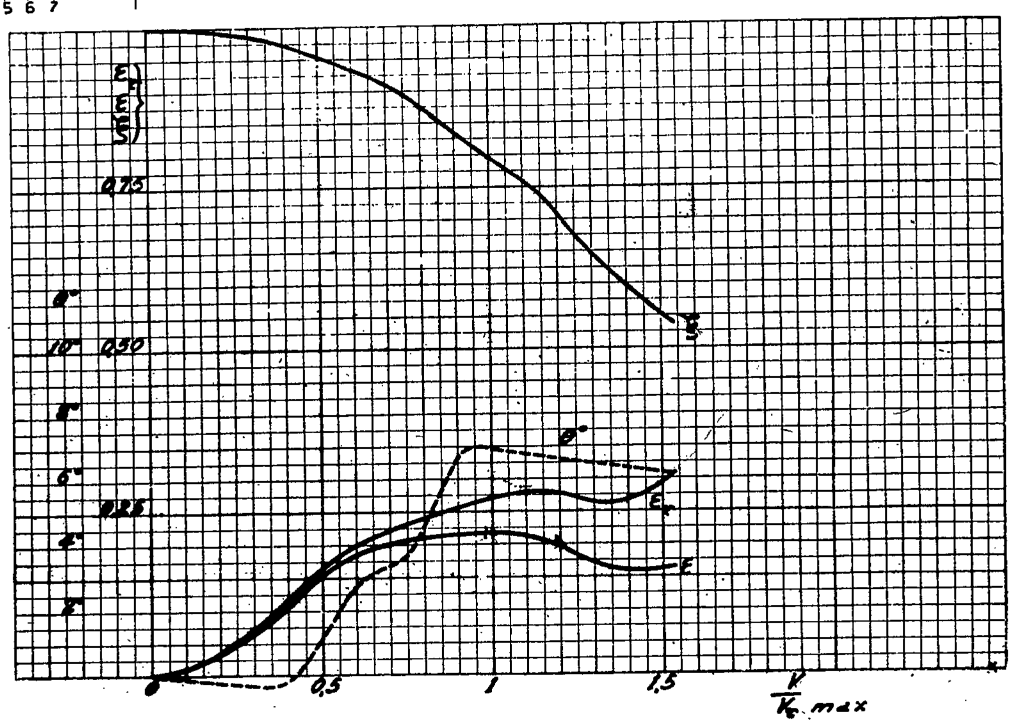
$M/l = 5.65$ $H/L = 0.119$ $M/L = L_1 = 0.380$ and $L_2 = 0.620$

Distance of c.g. aft of F.P.	$X = 328$ mm
Distance of c.g. above base line	$Y = 151$ mm
Weight of model (to scale)	$P = 1.305$ kg
Height of thrust line above base line	$Y_T = 184$ mm

$M-X/M = 0.0454$ $X/H = 1.410$

P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
φ = angle of wing setting relative to water line = 7° 30'
d = track of twin floats Δ = weight on water
Scale of model 1 : 14.5

Figure 11.



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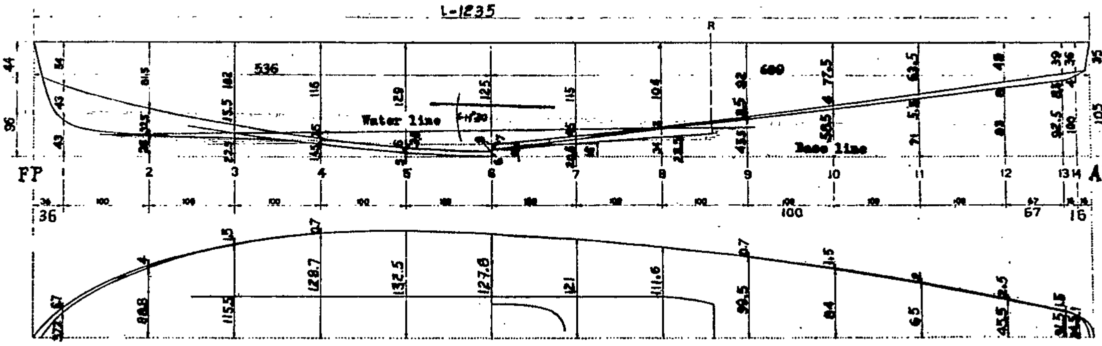
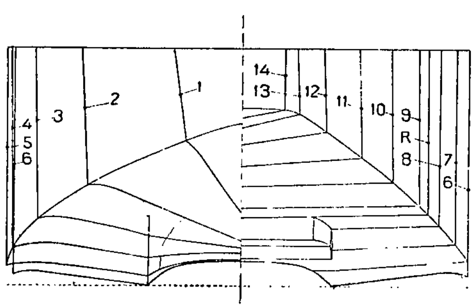




Length between perpendiculars	$L = 1235$ mm
Beam, maximum	$l = 263$ mm
Depth	$H = 140$ mm
Distance of step aft of forward perpendicular (FP)	$M = L_1 = 536$ mm; $L_2 = 793$ mm
Beam at step	$b = b_1 = 255.6$ mm; $b_2 = 208$ mm

$M/l = 4.70$ $H/L = 0.113$ $M/L = L_1 = 0.434$ and $L_2 = 0.642$

Distance of c.g. aft of F.P.	$X = 516$ mm
Distance of c.g. above base line	$Y = 140$ mm
Weight of model (to scale)	$P = 2.241$ kg
Height of thrust line above base line	$Y_T = 220$ mm

$M-X/M = 0.373$ $Y/X = 1.240$

P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^0 = angle of wing setting relative to water line = $2^0\ 20'$
d = track of twin floats Δ = weight on water
Scale of model 1 : 25

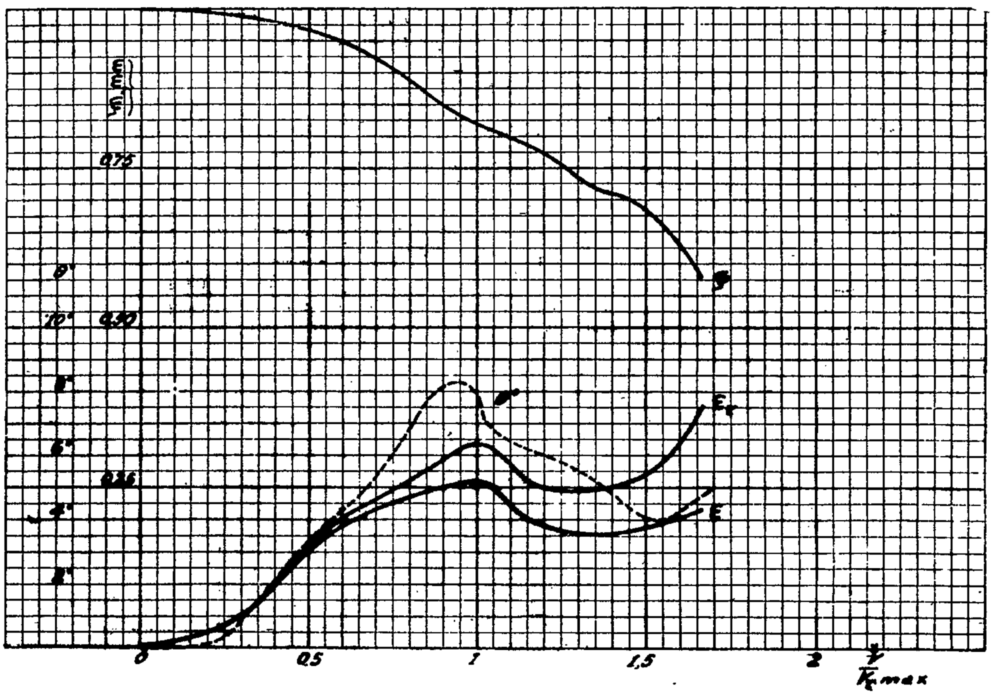
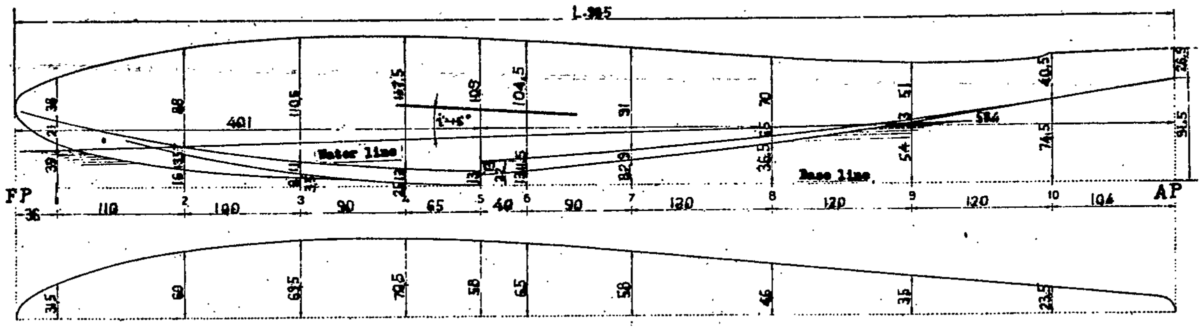
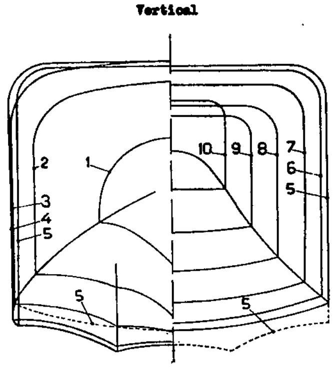


Figure 14.





Length between perpendiculars L = 995 mm
Beam, maximum l = 141 mm
Depth H = 133 mm
Distance of step aft of forward perpendicular (FP) M = 401 mm
Beam at step b = 136 mm
L/l = 7.06 H/L = 0.133 M/L = 0.403
Distance of c.g. aft of F.P. X = 386 mm
Distance of c.g. above base line Y = 131 mm
Weight of model (to scale) P = 1.750 kg
Height of thrust line above base line Y_T = 311 mm
$M-Y/M$ = 0.0375 Y/H = 0.985
P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^o = angle of wing setting relative to water line = 5°
d = track of twin floats Δ = weight on water
Scale of model 1 : 20

Figure 15.

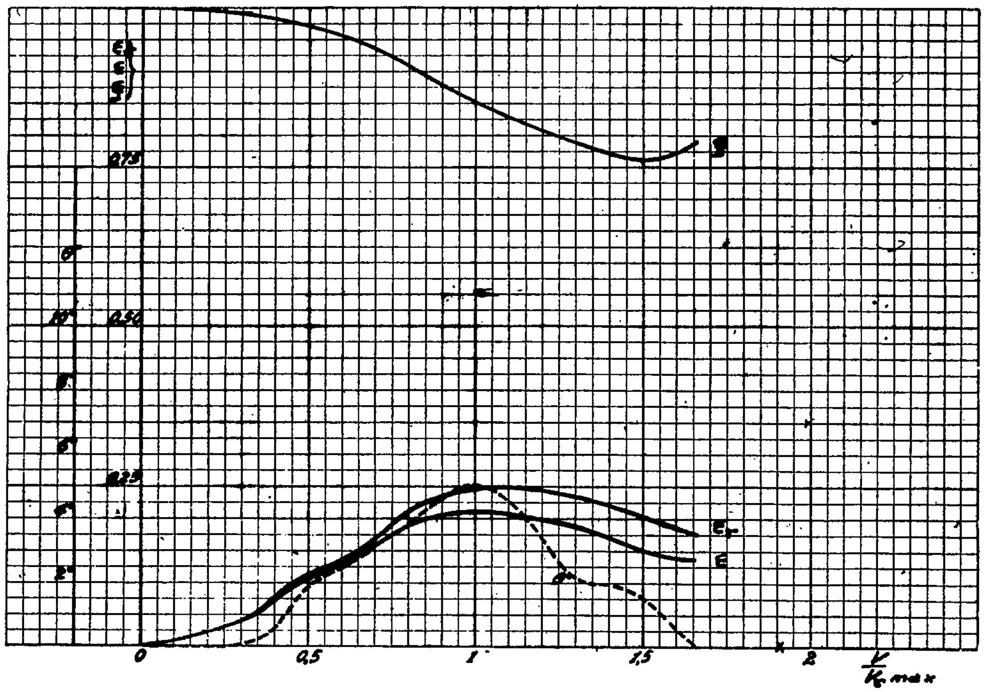
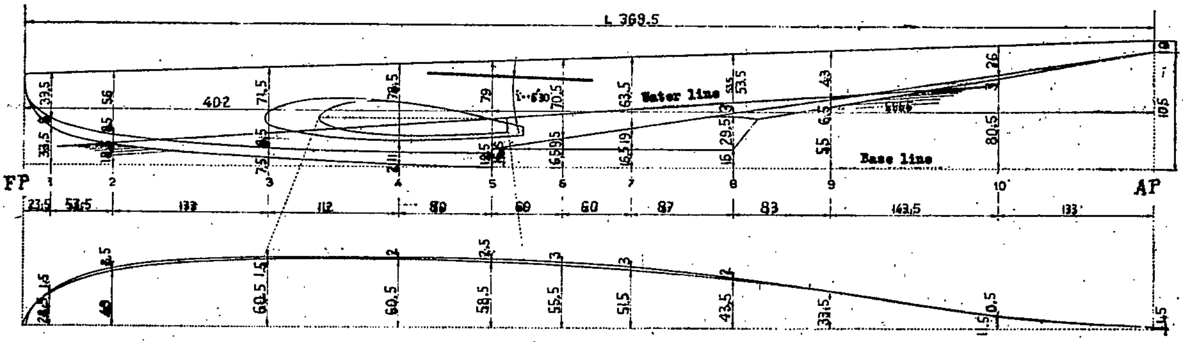
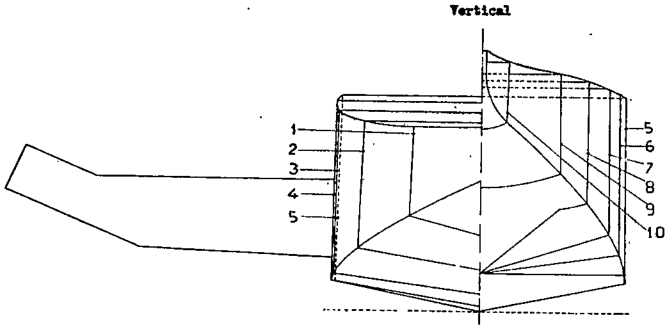


Figure 16.





Length between perpendiculars	L = 968.5 mm
Beam, maximum	l = 124 mm
Depth	H = 95.5 mm
Distance of step aft of forward perpendicular (FP)	M = 402 mm
Beam at step	b = 122 mm
L/l = 7.85 H/L = 0.098 M/L = 0.415	
Distance of c.g. aft of F.P.	X = 385 mm
Distance of c.g. above base line	Y = 161 mm
Weight of model (to scale)	P = 1.778 kg
Height of thrust line above base line	Y_T = 230 mm
M–X/M = 0.0364 Y/H = 1,680	

P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^0 = angle of wing setting relative to water line = 6° 30'
d = track of twin floats Δ = weight on water
Scale of model 1 : 15

Figure 17.

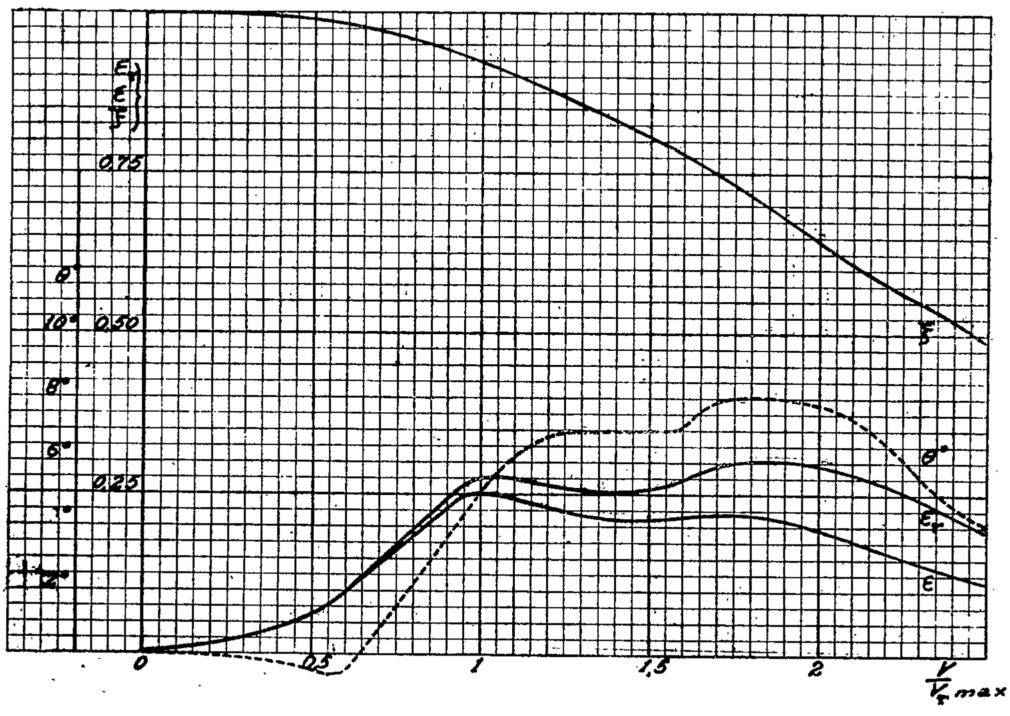
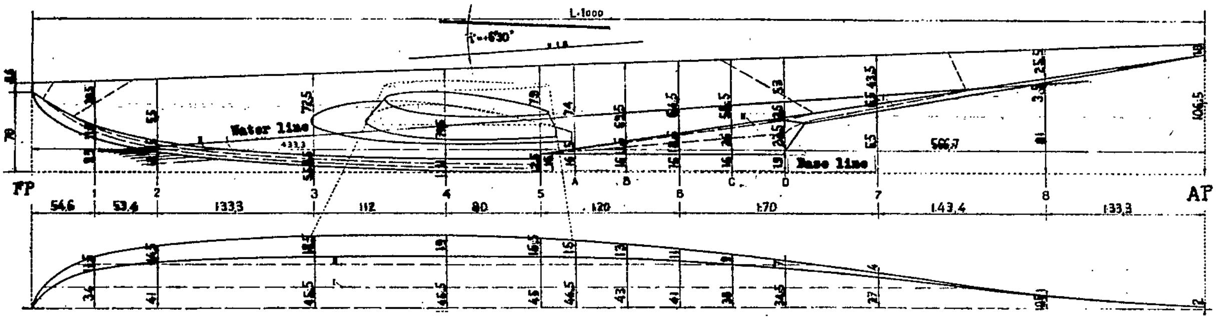
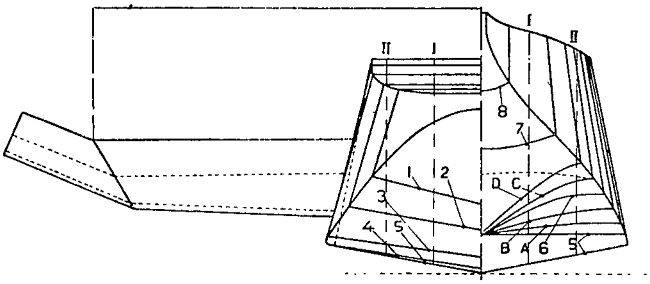


Figure 18.



Vertical



Length between perpendiculars L = 1000 mm
Beam, maximum l = 139 mm
Depth H = 95 mm
Distance of step aft of forward perpendicular (FP) M = 433.3 mm
Beam at step b = 123 mm
L/l = 7.75 H/L = 0.095 M/L = 0.433
Distance of c.g. aft of F.P. X = 420 mm
Distance of c.g. above base line Y = 161 mm
Weight of model (to scale) P = 1.778 kg
Height of thrust line above base line Y_T = 230 mm
M-X/M = 0.0130 Y/H = 1.700
P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^0 = angle of wing setting relative to water line = 6° 30'
d = track of twin floats Δ = weight on water
Scale of model 1 : 15

Figure 19.

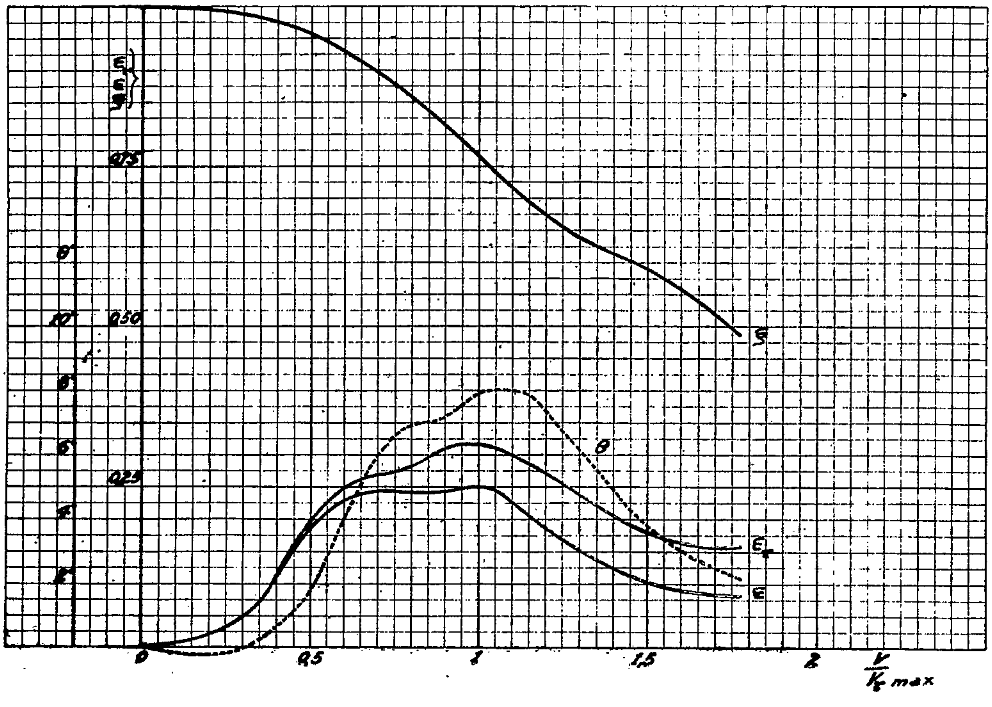
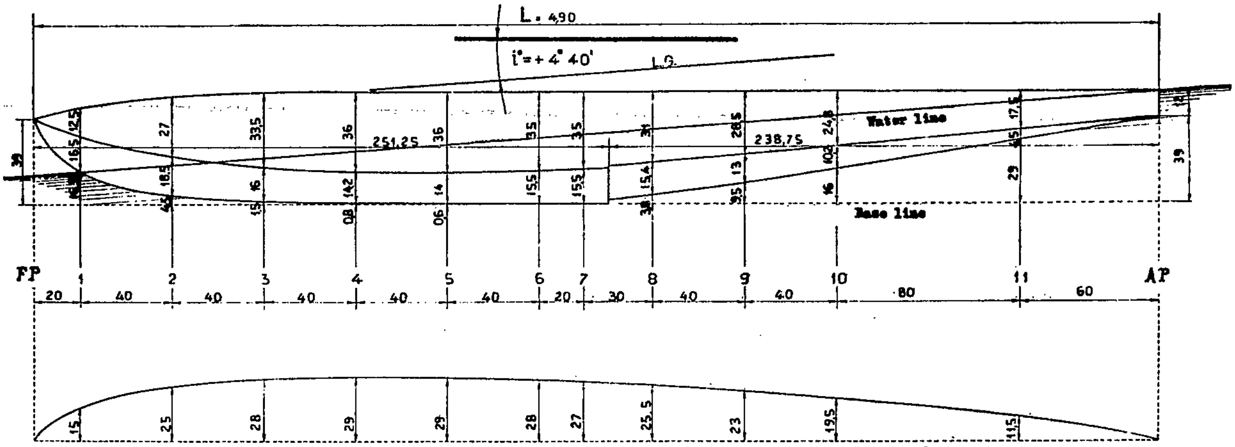
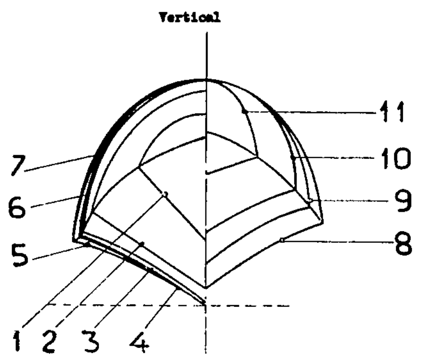


Figure 20.





Length between perpendiculars L = 490 mm
Beam, maximum l = 58 mm
Track of twin floats d = 200 mm
Depth H = 51 mm
Distance of step aft of forward perpendicular (FP) M = 251.25 mm
Beam at step b = 54 mm
L/l = 8.45 H/L = 0.104 M/L = 0.535 d/l = 3.45
Distance of c.g. aft of F.P. X = 240 mm
Distance of c.g. above base line Y = 149 mm
Weight of model (to scale) P = 0.350 kg.
Height of thrust line above base line Y_T = 149 mm
$M-X/M$ = 0.0445 Y/H = 2.920
P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^o = angle of wing setting relative to water line = 4° 40'
Δ = weight on water Scale of model 1 : 10

Figure 21.

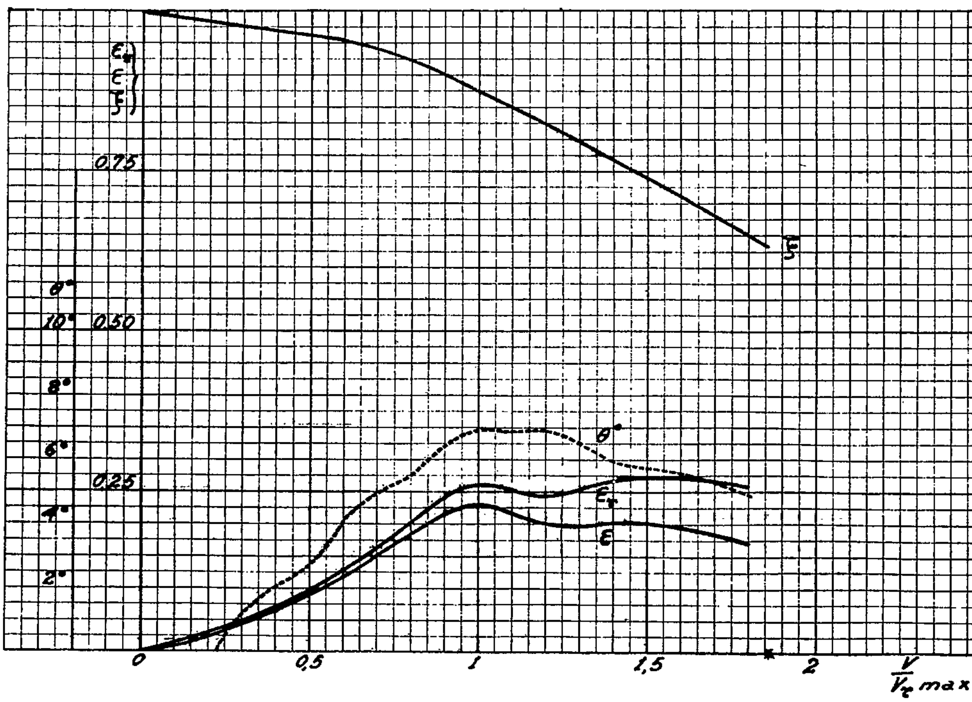
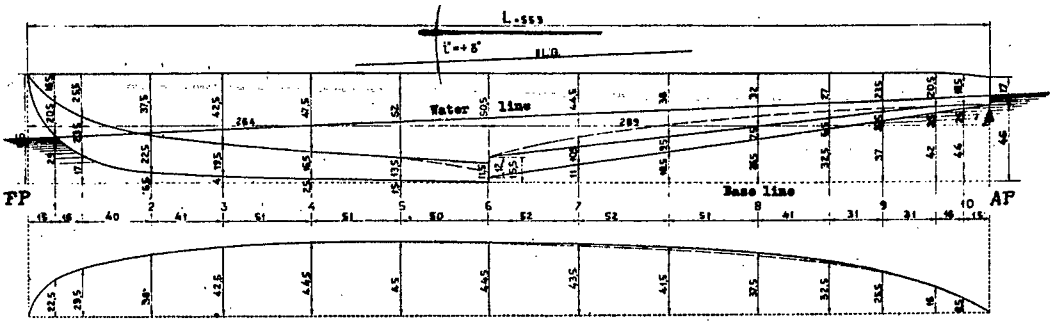
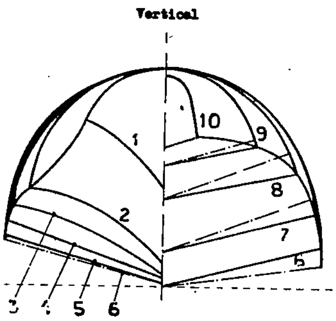


Figure 22.





Length between perpendiculars L = 553 mm
Beam, maximum l = 90 mm
Track of twin floats d = 370 mm
Depth H = 66 mm
Distance of step aft of forward perpendicular (FP) M = 264 mm
Beam at step b = 89 mm
L/l = 6.18 H/L = 0.119 M/L = 0.475 d/l = 4.12
Distance of c.g. aft of F.P. X = 253.3 mm
Distance of c.g. above base line Y = 152.7 mm
Weight of model (to scale) P = 0.740 kg
Reserve buoyancy V_t = 0.770 kg
Height of thrust line above base line Y_T = 172.7 mm
$M-X/M$ = 0.0193 Y/X = 2.280
P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^0 = angle of wing setting relative to water line = 3°
Δ = weight on water Scale of model 1 : 15

Figure 23.

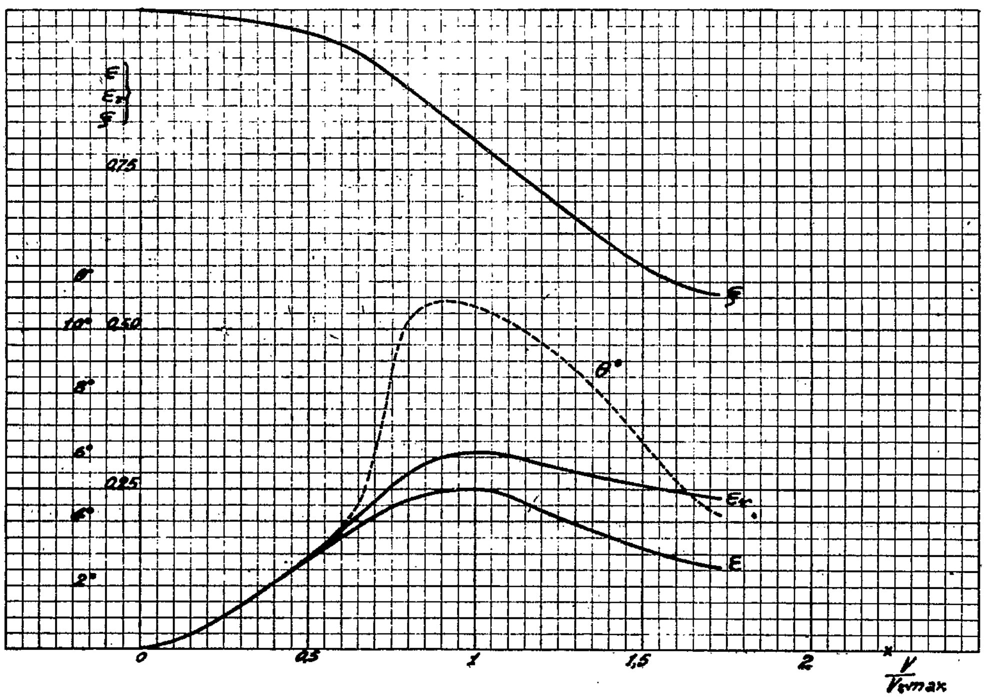
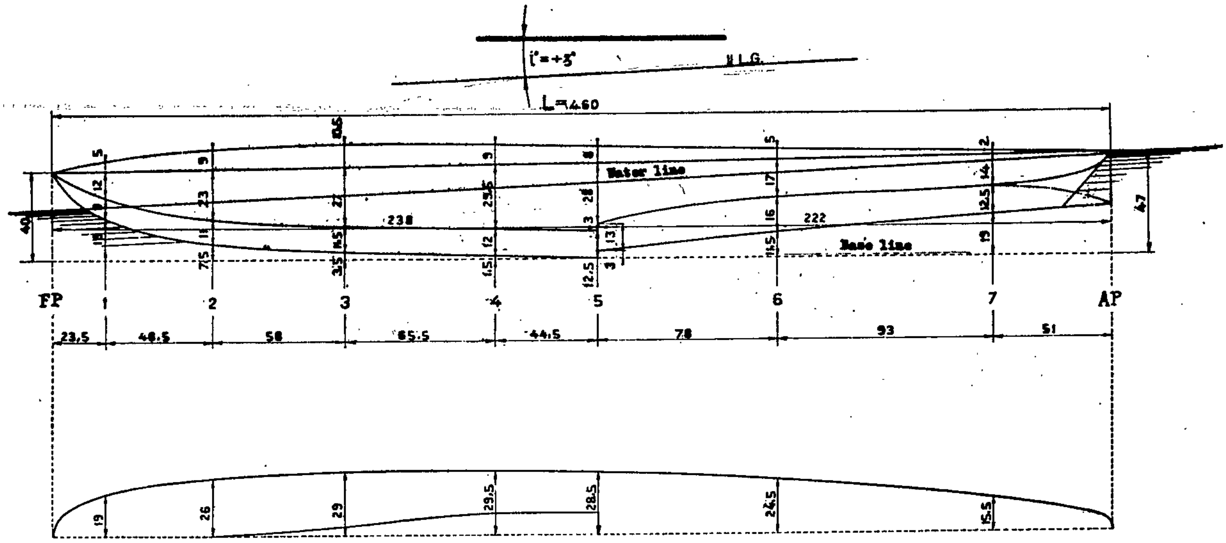
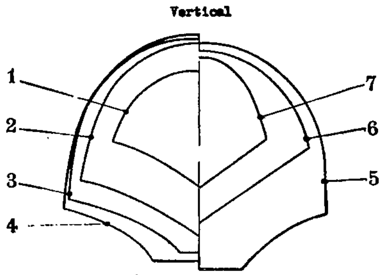


Figure 24.





Length between perpendiculars	L = 460 mm
Beam, maximum	l = 59 mm
Track of twin floats	d = 246.5 mm
Depth	H = 52.5 mm
Distance of step aft of forward perpendicular (FP)	M = 238 mm
Beam at step	b = 57 mm
L/l = 7.80 H/L = 0.114 M/L = 0.518 d/l = 4.18	
Distance of c.g. aft of F.P.	X = 218 mm
Distance of c.g. above base line	Y = 139 mm
Weight of model (to scale)	P = 0.743 kg
Reserve buoyancy	V_t = 0.532 kg
Height of thrust line above base line	Y_T = 152.8 mm
M-X/M = 0.0084 H/Y = 2.650	

P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^o = angle of wing setting relative to water line = 3°
Δ = weight on water   Scale of model 1 : 15

Figure 25.

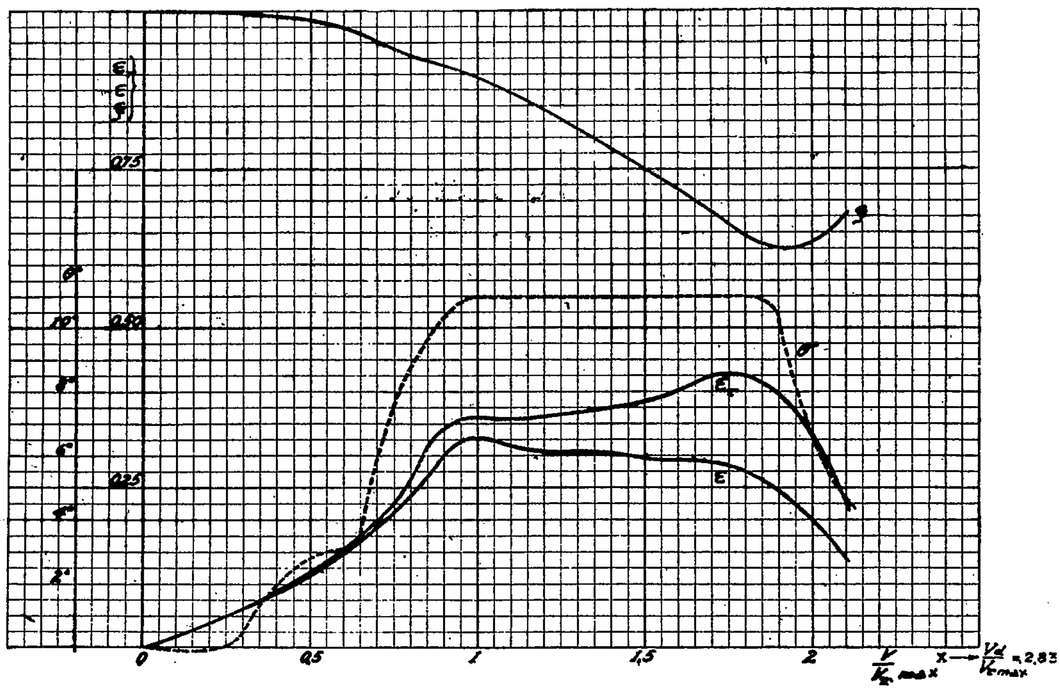
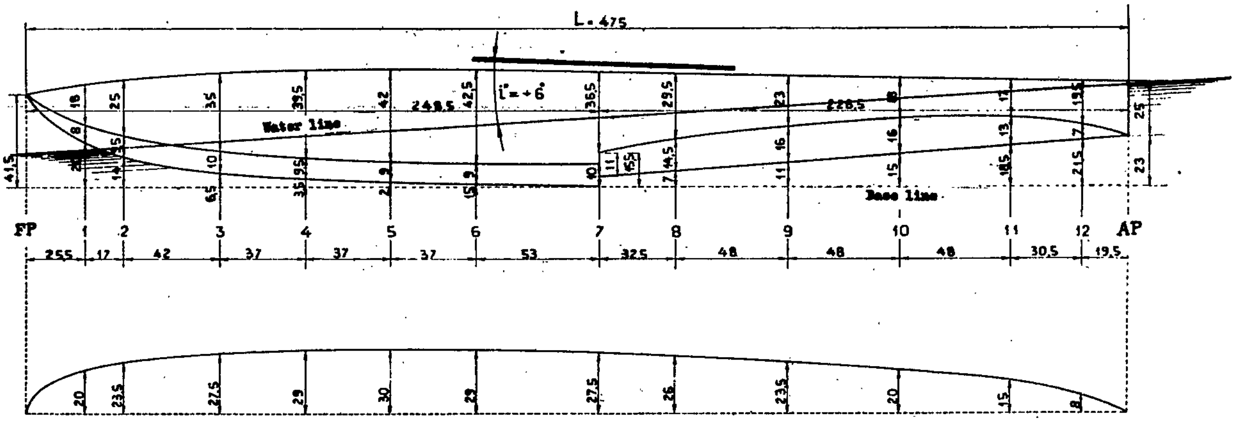
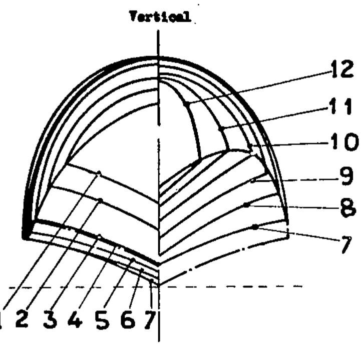


Figure 26.





Length between perpendiculars	L = 475 mm
Beam, maximum	l = 60 mm
Track of twin floats	d = 193 mm
Depth	H = 53 mm
Distance of step aft of forward perpendicular (FP)	M = 248.5 mm
Beam at step	b = 55 mm

$L/l = 7.91$ $H/L = 0.111$ $M/L = 0.523$ $d/l = 3.22$

Distance of c.g. aft of F.P.	X = 233.5 mm
Distance of c.g. above base line	Y = 87 mm
Weight of model (to scale)	P = 0.803 kg
Reserve buoyancy	V_t = 0.467 kg
Height of thrust line above base line	Y_T = 94 mm

$M-X/M = 0.0534$ $Y/X = 1.645$

P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^0 = angle of wing setting relative to water line = 6°
Δ = weight on water   Scale of model 1 : 10

Figure 27.

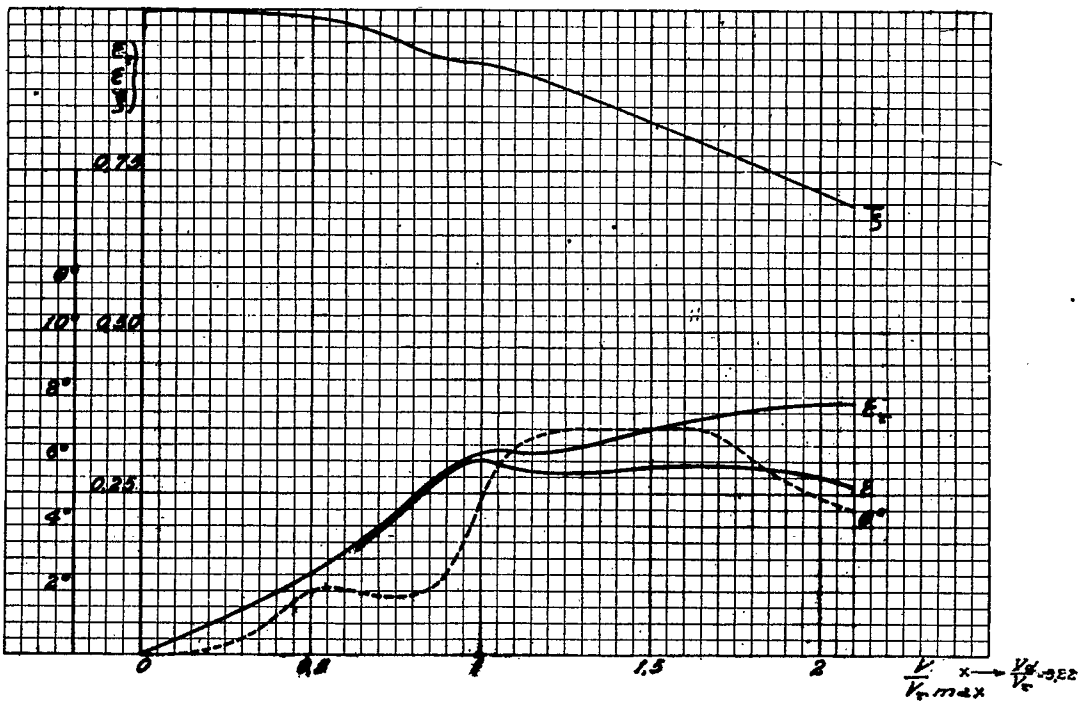
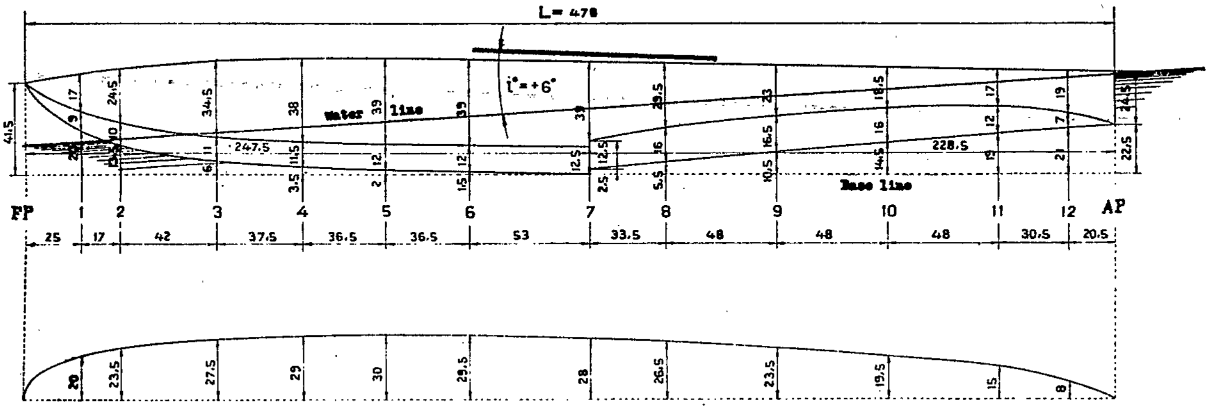
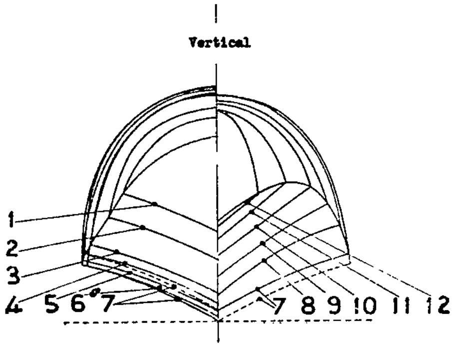


Figure 28





Length between perpendiculars L = 476 mm
Beam, maximum l = 60 mm
Track of twin floats d = 320 mm
Depth H = 53 mm
Distance of step aft of forward perpendicular (FP) M = 247.5 mm
Beam at step b = 56 mm
L/l = 7.93 H/L = 0.111 M/L = 0.520 d/l = 5.34
Distance of c.g. aft of F.P. X = 232.5 mm
Distance of c.g. above base line Y = 87 mm
Weight of model (to scale) P = 0.803 kg
Reserve buoyancy V_t = 0.457 kg
Height of thrust line above base line Y_T = 94 mm
M-X/M = 0.0628 Y/H = 1.640
P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^0 = angle of wing setting relative to water line = 6°
Δ = weight on water Scale of model 1 : 10

Figure 29.

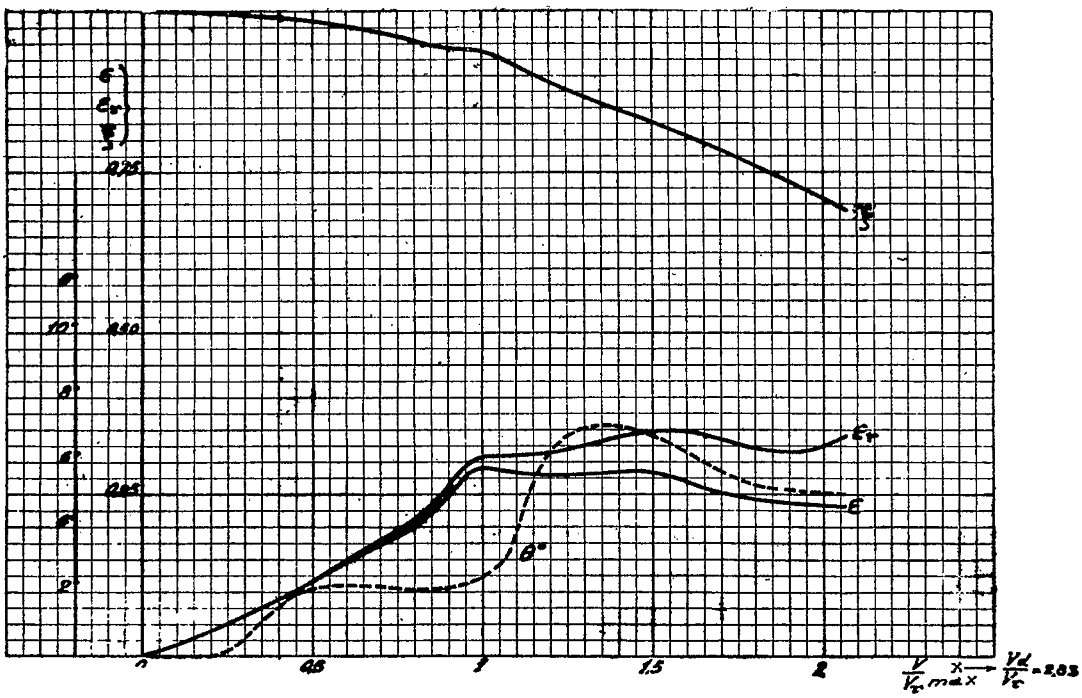
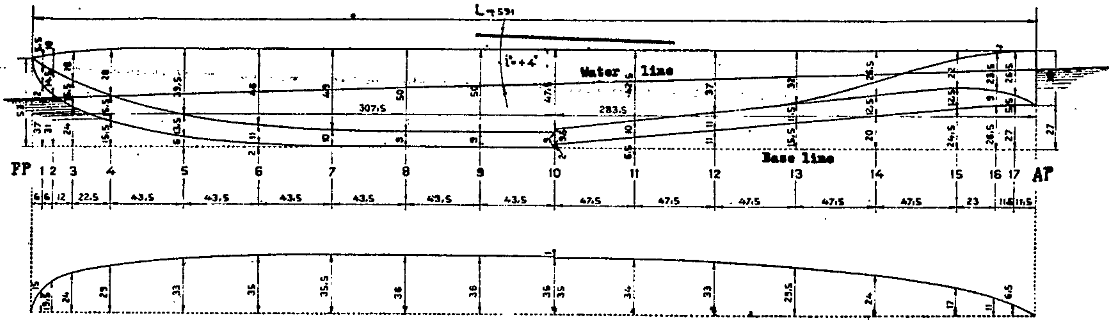
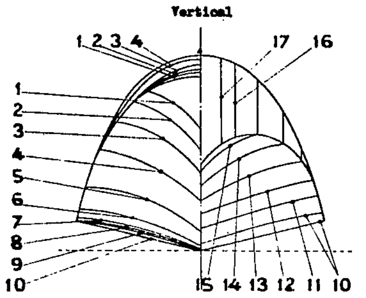


Figure 30.





Length between perpendiculars L = 591 mm
Beam, maximum l = 74 mm
Track of twin floats d = 320 mm
Depth H = 74 mm
Distance of step aft of forward perpendicular (FP) M = 307.5 mm
Beam at step b = 74 mm
L/l = 7.98 H/L = 0.125 M/L = 0.523 d/l = 4.32
Distance of c.g. aft of F.P. X = 287.5 mm
Distance of c.g. above base line Y = 179 mm
Weight of model (to scale) P = 1.333 kg
Reserve buoyancy V_t = 0.993 kg
Height of thrust line above base line Y_T = 179 mm
M-X/M = 0.0650 Y/H = 2.420
P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^0 = angle of wing setting relative to water line = 4^0
Δ = weight on water Scale of model 1 : 15

Figure 31.

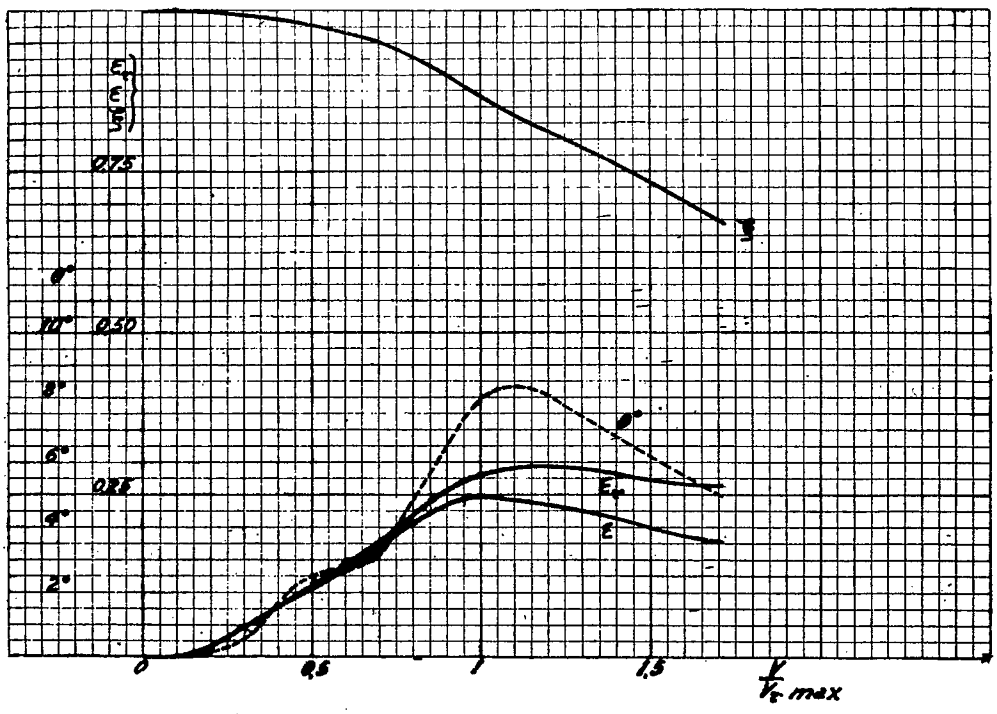
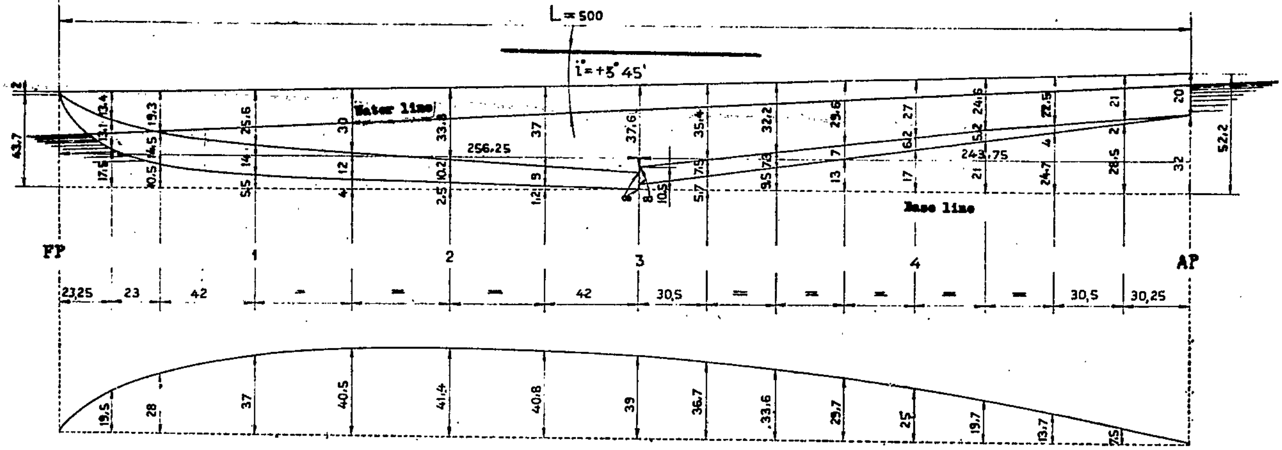
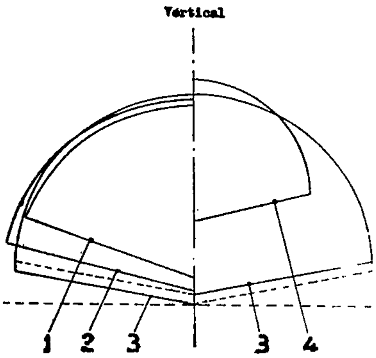


Figure 32.





Length between perpendiculars L = 500 mm
Beam, maximum l = 82.8 mm
Depth H = 48.1 mm
Distance of step aft of forward perpendicular (FP) M = 356.25 mm
Beam at step b = 78 mm
L/l = 6.05 H/L = 0.095 M/L = 0.511
Distance of c.g. aft of F.P. X = 246.25 mm
Distance of c.g. above base line Y = 139 mm
Weight of model (to scale) P = 0.462 kg
Reserve buoyancy V_t = 0.356 kg
Height of thrust line above base line Y_T = 134 mm
M-X/M = 0.0390 Y/H = 2.88
P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i^o = angle of wing setting relative to water line = 3° 45'
d = track of twin floats Δ = weight on water
Scale of model 1 : 16

Figure 33.

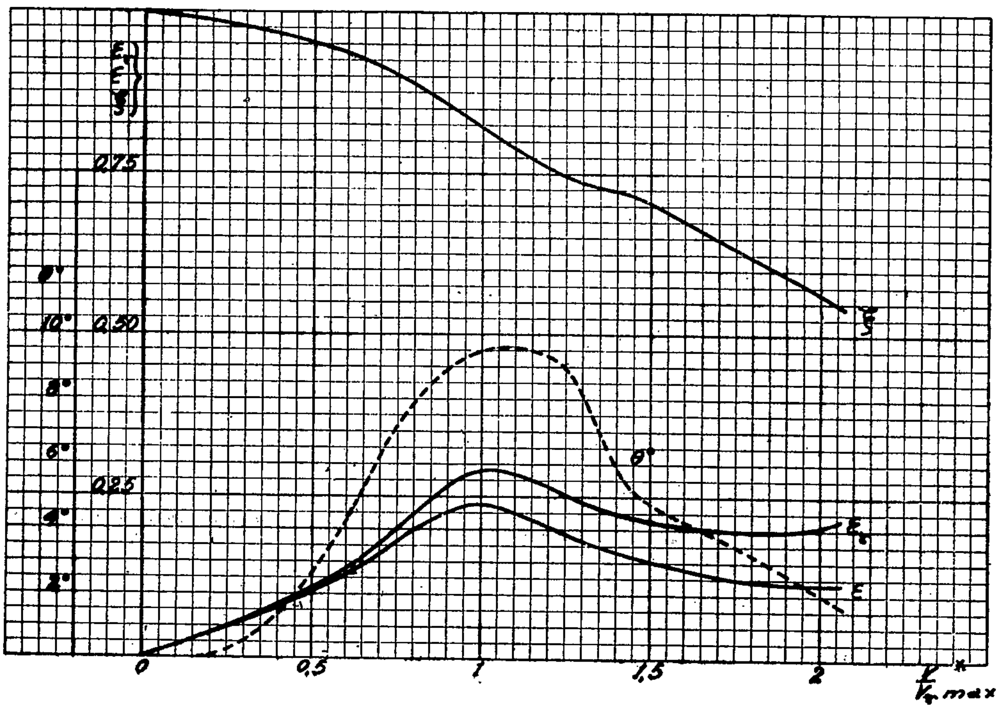
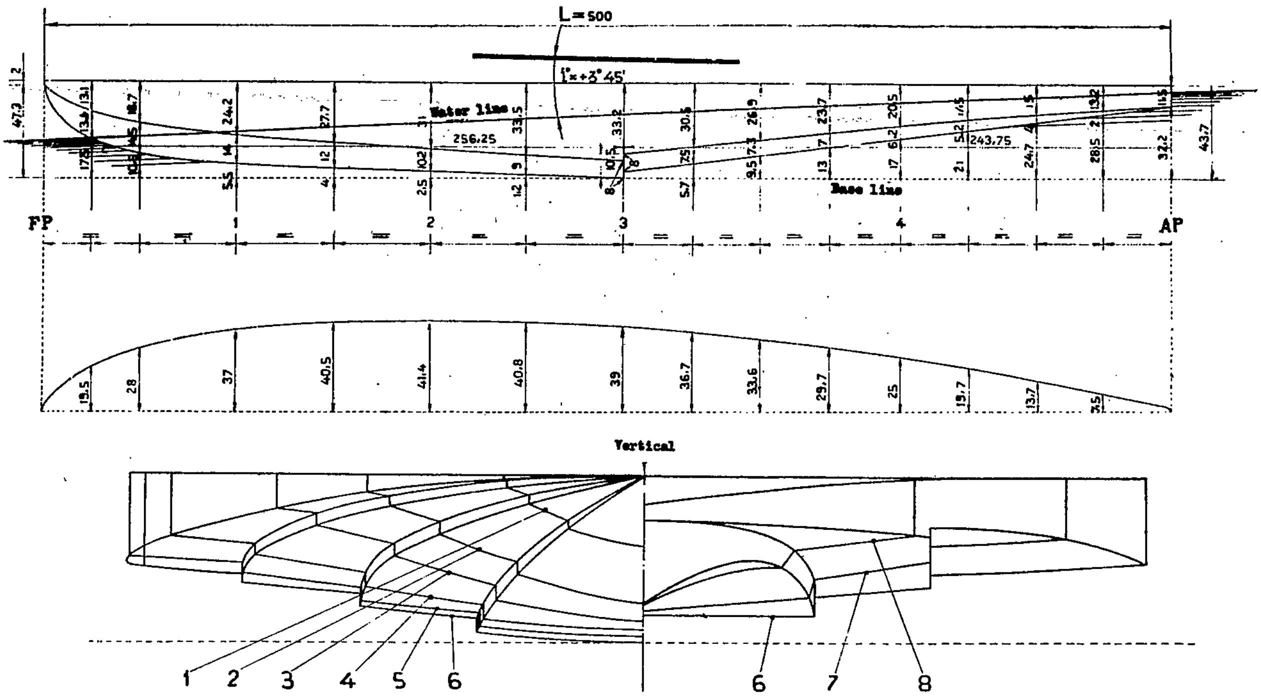


Figure 34.



Length between perpendiculars L = 600 mm
Beam, maximum l = 295 mm
Depth H = 50 mm
Distance of step aft of forward perpendicular (FP) M = 346 mm
Beam at step b = 306 mm
$L/l = 2.07$ $H/L = 0.084$ $M/L = 0.578$
Distance of c.g. aft of F.P. X = 308 mm
Distance of c.g. above base line Y = 171.5 mm
Weight of model (to scale) P = 1.720 kg

Reserve buoyancy V_t = 2.240 kg
Height of thrust line above base line Y_T = 175 mm
$M-X/M = 0.0110$ $Y/H = 3.42$
P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
1^0 = angle of wing setting relative to water line = 2° 21'
d = track of twin floats Δ = weight on water
Scale of model 1 : 10

Figure 35.

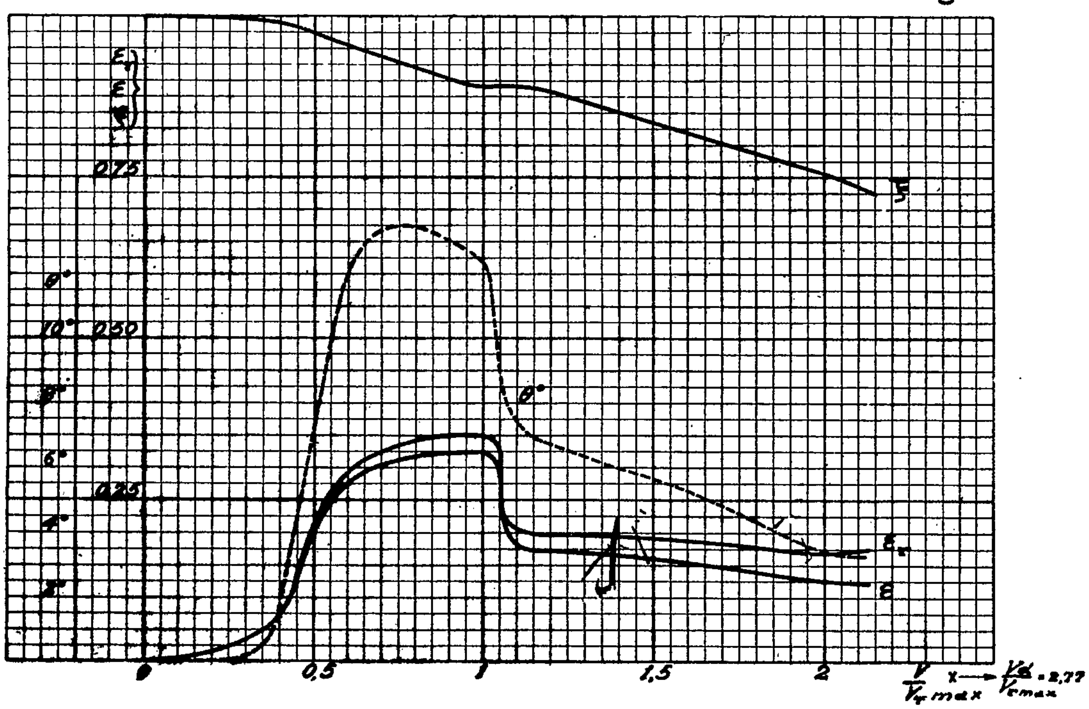
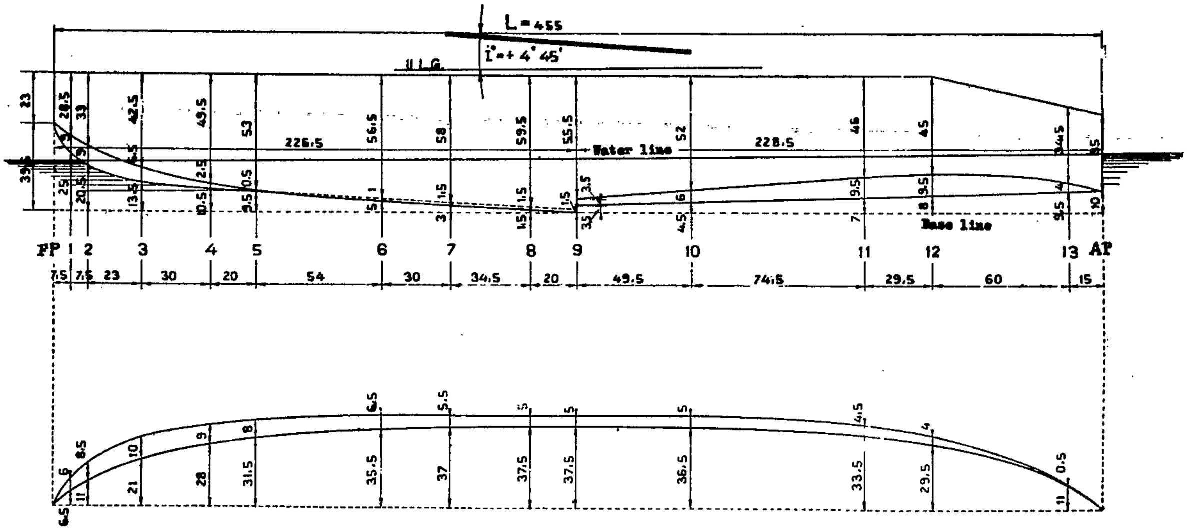
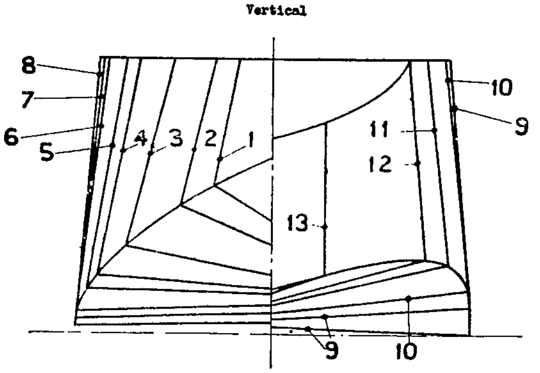


Figure 36.





Length between perpendiculars	L = 455 mm
Beam, maximum	l = 85 mm
Track of twin floats	d = 234 mm
Depth	H = 62.5 mm
Distance of step aft of forward perpendicular (FP)	M = 226.5 mm
Beam at step	b = 85 mm
L/l = 5.35 H/L = 0.137 M/L = 0.497 d/l = 2.64	
Distance of c.g. aft of F.P.	X = 222 mm
Distance of c.g. above base line	Y = 96 mm
Weight of model (to scale)	P = 0.812 kg
Height of thrust line above base line	Y_T = 190 mm
M-X/M = 0.0198 Y/H = 1.53	

P_T = weight of full size
α = angle of tangent at water line forward
β_1 = angle between fore and afterbody keels
β_2 = angle between forebody keel and keel aft of second step
i° = angle of wing setting relative to water line = 4° 45'
Δ = weight on water Scale of model 1 : 20

Figure 37.

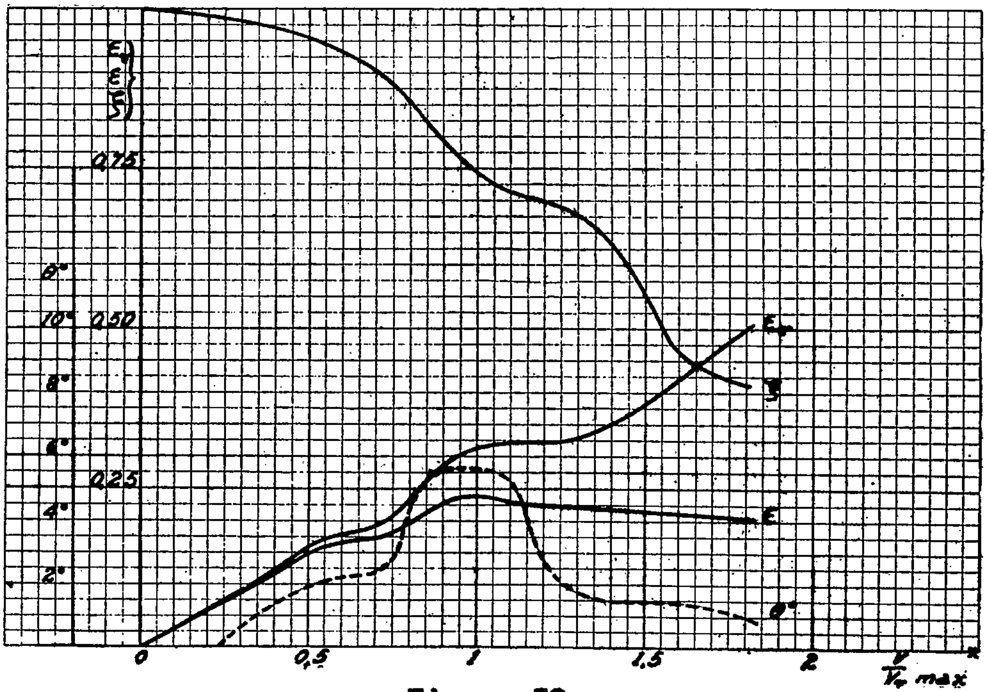


Figure 38.